Influence of wine polysaccharides on white and red wine mouthfeel

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INTRODUCTION

The style and quality of wine is partially determined by its mouthfeel, which includes the sensations of viscosity, astringency and warmth or hotness. Previous work at the AWRI has focussed on the effects of phenolics on wine texture (Gawel *et al.* 2014a). It showed that low molecular weight (MW) phenolics contribute to the perception of viscosity, astringency, palate hotness and bitterness in white wines, but their effects were strongly dependent on the wines' pH and ethanol content. The focus of more recent work has shifted to investigating the effects of polysaccharides on mouthfeel and taste. Earlier work (Dupin *et al.* 2000, Vernhet *et al.* 1999) showed that polysaccharides can act as 'protective colloids' that assist in achieving protein and tartrate stability, thereby reducing bentonite use and energy costs. From a sensory perspective, polysaccharides have the potential to affect all aspects of mouthfeel including perception of astringency, viscosity and hotness. This occurs via interactions with phenolics and most likely by changing the molecular interplay between water and ethanol, which ultimately affects how the polysaccharides interact with the taste and tactile receptors in the mouth (Gawel *et al.* 2017).

AT A GLANCE

- Mouthfeel attributes such as viscosity, astringency and hotness play an important role in wine quality and are known to be influenced by the macromolecules present in wine
- Several studies investigated the sensory impact of adding polysaccharides to a range of model and real wines
- While some impacts were seen on the perception of viscosity and hotness, the basic wine matrix (pH and alcohol) had a much greater effect on mouthfeel and taste than the polysaccharides
- Higher pH wines generally had greater perceived viscosity, bitterness and lower astringency, and higher alcohol wines were perceived as more bitter, astringent and hot
- Winemaking practices that increase the concentration of certain polysaccharides have potential to mask palate hotness in both white and red wine, but practices that change wine pH and alcohol will probably have a greater impact.

WHAT ARE POLYSACCHARIDES AND WHERE DO THEY COME FROM?

Polysaccharides are an abundant and diverse group of wine macromolecules (Figure 1). They are found at concentrations of 100-250mg/L in white wines and up to 600mg/L in red wines. As their name suggests, they are made up mostly of sugars (typically 80-90% by weight), and are the highest MW compounds found in wine, ranging from around 10,000 to 250,000 units (which for perspective is up to 100 times greater than the average MW of a red wine tannin).

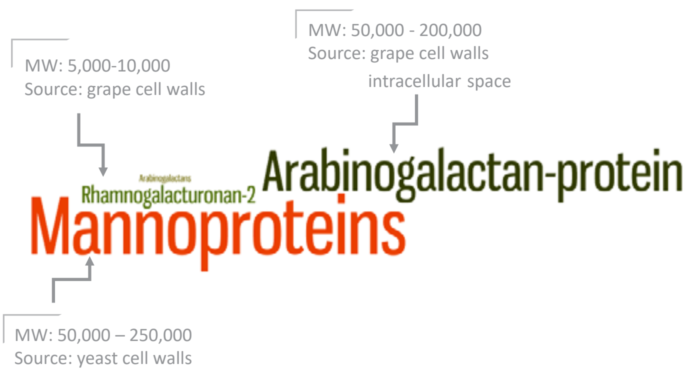

Figure 1. Polysaccharides in wine. The size of the text indicates the typical relative concentrations found in white wines.

They can be classified into three major groups based on the relative proportions and specific types of sugars they are made from, and their likely source during winemaking. These are:

Mannoproteins (MPs), which are extracted into wine from yeast cell walls during fermentation and later during contact with yeast lees. At up to 250,000 MW units, they are the largest polysaccharides, and can be differentiated chemically by the presence of their 'signature' sugar mannose

Arabinogalactan proteins (AGPs), which are grape derived and are easily released during juice processing and the early stages of fermentation. As their name suggests, they contain a significant proportion of the sugars arabinose and galactose

Rhamnogalacturonan-2 polysaccharides (RG-2), which are the lowest MW polysaccharides and are released from pectins found in the grape cell wall when skins are in contact with juice or fermenting must. They are the most negatively charged of all polysaccharide types at wine pH and contain a high proportion of the sugars galacturonic acid and rhamnose, as well as their unique (and therefore identifying) sugar, fucose.

This report summarises the results of trials investigating the impact of polysaccharides on the mouthfeel and taste of red and white model wines and 'real' white wines.

ADDING POLYSACCHARIDES TO DIFFERENT WINES

Total (whole) polysaccharides were extracted from Chardonnay, Riesling and Shiraz wines after being stripped of phenolics, and in the case of white wines, proteins. The whole polysaccharides were fractionated on a scale necessary to obtain sufficient quantities for sensory assessment into high molecular weight MW (>93kDa), medium MW (13-93kDa) and low MW (5-12kDa) fractions. The composition of the fractions was determined by their sugar profiles and reported MWs (Figure 2). The fractions were added to different types of wine (real and model), and sensory evaluations were conducted. The sensory evaluations of the different wine types were conducted separately, but essentially used the same panel and profiling methods. A panel of 10-12 trained tasters profiled the taste, mouthfeel (viscosity, astringency and palate hotness) and overall flavour of the wines with and without added polysaccharides (Gawel *et al.* 2016) using descriptive analysis methods.

SENSORY EFFECTS OF ADDED POLYSACCHARIDES

Whole white wine polysaccharides at the wine-like concentration of 150mg/L were added to a low phenolic white wine and an equivalent wine with added white wine phenolics. This addition of polysaccharides, which effectively doubled their typical concentration, increased perceived viscosity,

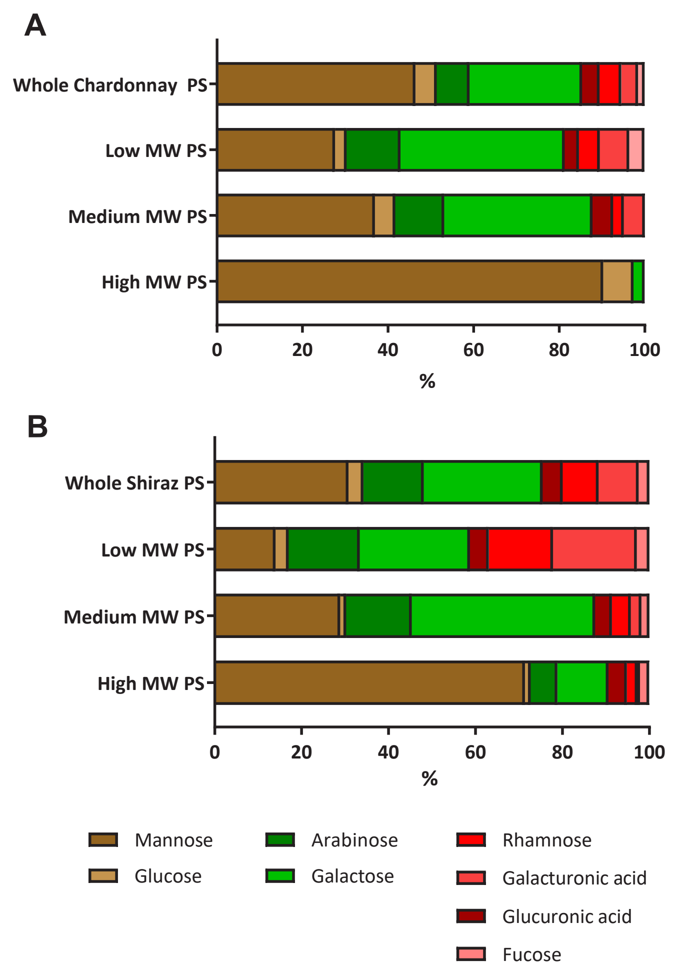

Figure 2. Monosaccharide composition of the whole polysaccharides and fractions derived from (A) Chardonnay and (B) Shiraz wines. Brown/orange indicates mannoproteins, green indicates AGPs, and red/pink represents RG-2.

with a greater effect seen in the higher phenolic white wine (Figure 3). This suggests that phenolics and polysaccharides may interact to produce a perception of increased viscosity in white wine. Polysaccharides are used in many food and beverage industries as 'thickeners' and texture modifiers. However, viscosity increases from polysaccharides are thought to occur when they become molecularly entangled, which only occurs when they are present in higher concentrations than those found in wine. As such, the observed increases in perceived viscosity in wine probably result from another mechanism, likely involving interactions with phenolics.

Other effects that were noted from the addition of the whole polysaccharides to white wine included decreases in perceived hotness in both high and low phenolic wines and an increase in perceived bitterness in the low phenolic wine (Figure 3). The reason for the increase is unclear. However, in the red wine model system, the medium MW polysaccharides reduced bitterness, particularly in the case of the model wines representing lighter bodied (i.e., lower alcohol and lower pH) styles.

Adding the same amount of whole red wine polysaccharides (150mg/L) to a model red wine that included 0.5g/L grape tannins did not increase its perceived viscosity. Red wine polysaccharides generally differ in composition from white wine polysaccharides by having significantly more (skin-derived) rhamnogalacturonans (Figure 2) which could explain the difference in their effect on perceived wine viscosity. Any increases in viscosity of the model red wines due to polysaccharides may have also been masked by astringency. However, further work showed that certain types of polysaccharides in red wines can increase perceived viscosity under the conditions of higher alcohol and higher pH. Most importantly from a winemaking perspective, white and red wine polysaccharides were shown to significantly reduce the perception of palate hotness – a result which may explain why some wines appear to be less hot on the palate than others even though they have the same or higher alcohol content.

DELVING DEEPER

The next questions to explore were: Which of the polysaccharide types found in wine could have caused the reduction in palate hotness and increase in viscosity? And how can they be better incorporated into wine through winemaking practices? To find out, further studies were conducted that involved tasting polysaccharide fractions taken from white and red wine, in model wines with different wine pH and ethanol levels. This work also examined the contribution of polysaccharides to mouthfeel compared with that of the wine matrix components of pH and alcohol.

All results to date point to medium MW (13-93kDa) polysaccharides being implicated in increased perceived viscosity and reductions in perceived hotness. However, it is noteworthy that their effects are dependent on wine pH and alcohol level. These polysaccharides increased the perceived viscosity of both red and white model wines when pH and alcohol were higher (pH 3.6 and alcohol 13.5%v/v), and decreased perceived hotness only when the alcohol content of the model wine was low (data for white model wine shown in Figure 4).

The sensorially significant medium MW fraction contained

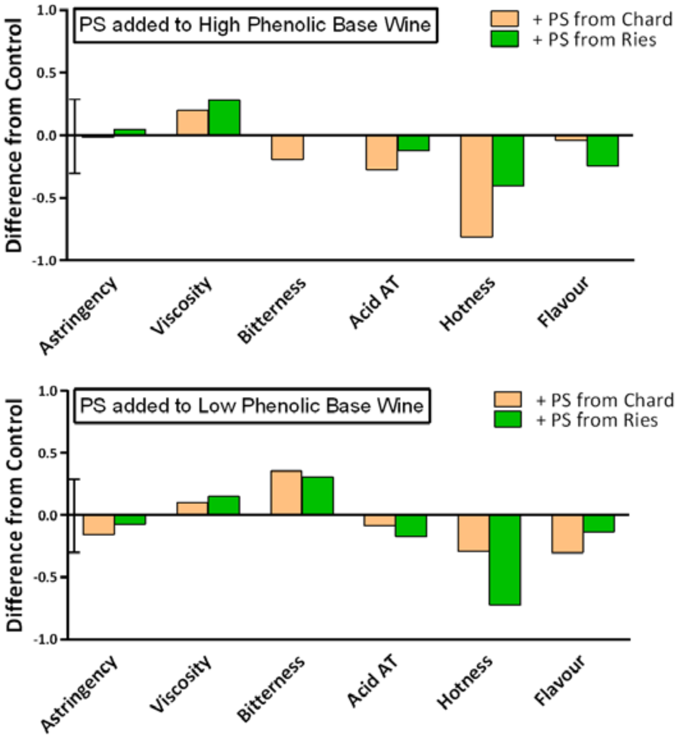

Figure 3. Effect of adding whole white wine polysaccharides on the mouthfeel and taste of a low and high phenolic white wine. AT = aftertaste, PS = polysaccharides

a high proportion of AGPs (Figure 2), which in the case of red wine ferments are known to be rapidly extracted during the early stages of fermentation but are lost thereafter. Whether the same dynamics apply during white wine fermentation and whether the dynamics change following fermentation is a subject of a current study at the AWRI. This work aims to give winemakers leads as to how to retain palate-cooling polysaccharides during winemaking.

Earlier work by AWRI researchers showed that the astringency produced by seed tannins was suppressed by rhamnogalacturans, and their bitterness was suppressed by a mixture of mannoproteins and AGPs (Vidal *et al.* 2004a,b). Polysaccharides are thought to suppress the astringency and bitterness of tannins by forming complexes that cannot interact with salivary and other oral proteins involved in astringency and bitterness perception.

The current work went further by investigating if and how the wine matrix influences these interactions. It was found that the astringency of only the higher alcohol model red wines was reduced by polysaccharides, with the low MW fraction being the most suppressive. The medium weight polysaccharides reduced bitterness of the lower alcohol and higher pH wines.

EFFECT OF THE WINE MATRIX

The wine matrix can be considered the 'elephant in the room' in this work. All the data collected show that the basic wine matrix had a comparatively much greater effect on mouthfeel and taste than the polysaccharides. Higher pH mostly resulted in greater perceived viscosity, bitterness and lower astringency, and higher alcohol wines were more bitter, astringent and hot. Polysaccharides tended to modulate the effects of the wine matrix on mouthfeel, but pH and alcohol levels were the main drivers of mouthfeel and taste (Figures 4 and 5).

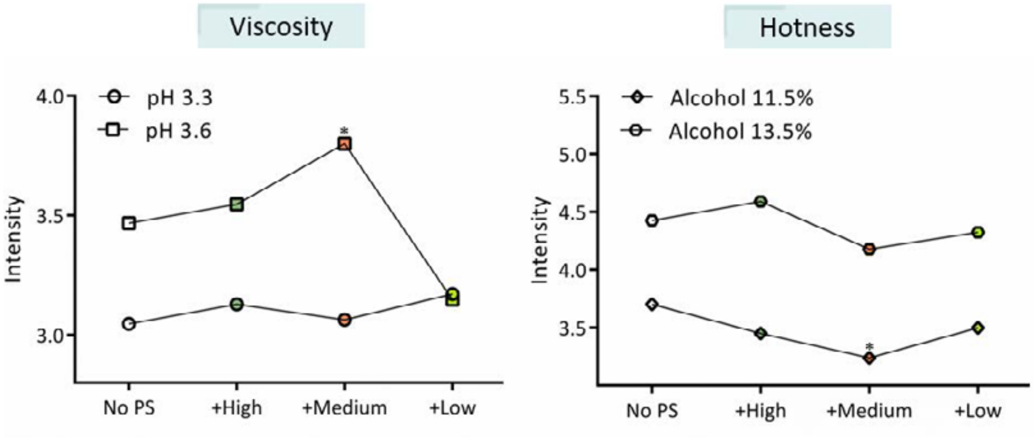

Figure 4. Interactive effects between polysaccharide MW fraction and pH or alcohol in model white wines. * indicates significantly different from the no polysaccharides control (p<0.1). PS = polysaccharides.

The relative influence of wine matrix composition and polysaccharides has significant winemaking implications. The pH and alcohol content of a wine can be easily influenced by applying standard winemaking practices (e.g. acid, tannin and water additions or malolactic fermentation). Achieving a significant increase in polysaccharide concentration in wine is more difficult. For example, it was previously found that an extensive range of white juice extraction methods representative of commercial winemaking only yielded differences in polysaccharide concentration in the order of 15% (Gawel *et al.* 2014b). Although higher polysaccharides in wine can be achieved using other winemaking approaches, such as fermenting juices on grape solids and maintaining wine on yeast lees, results from this work suggest that the mouthfeel effects of these increases in polysaccharides are unlikely to rival that of the wine matrix itself.

SUMMARY

In-mouth textural attributes play a significant role in the perceived quality of both white and red wine. Polysaccharides, which are a chemically diverse and relatively abundant group of compounds in wine, were shown to influence wine mouthfeel and taste. However, it was clear that different polysaccharide types affected mouthfeel differently and their effects were strongly influenced by wine pH and alcohol level. Work is currently under way at the AWRI that seeks to understand how winemaking practices affect different types of polysaccharides. If practices can be identified that specifically enhance the concentration of medium MW polysaccharides, they could be used to mask negatively perceived ethanol-derived hotness, and enhance perceived viscosity in some wines. Overall, however, changes to the wine matrix – namely pH and ethanol – are likely to have a greater influence on mouthfeel than polysaccharides.

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REFERENCES

Dupin, I.V.S.; Stockdale, V.J.; Williams P.J.; Jones, G.P.; Markides, A.J. and Waters, E.J. (2000) *Saccharomyces cerevisiae* mannoproteins that protect wine from protein haze: evaluation of extraction methods and immunolocalisation. J. Agric. Food Chem. 48:1086–1095.

Gawel, R.; Smith, P.A.; Cicerale, S. and Keast, R.J. (2017) The mouthfeel of white wine. Crit. Rev. Food Sci. Nutr. doi: 10.1080/10408398.2017.1346584

Gawel, R.; Smith, P.A. and Waters, E.J. (2016) The influence of polysaccharides on the taste and mouthfeel of white wine. Aust. J. Grape Wine Res. 22:350-357.

Gawel, R.; Godden, P.; Williamson, P.; Francis, L.; Smith, P.; Waters, L.; Herderich, M. and Johnson, D. (2014a) Influence of phenolics on white wine quality and style. Wine Vitic. J. May/June:34-36.

Gawel, R.; Day, M.; Van Sluyter, S.C.; Holt, H.; Waters, E.J. and Smith, P.A. (2014b) White wine taste and mouthfeel as affected by juice extraction and processing. J. Agric. Food Chem. 62:10008-10014.

Vernhet, A.; Dupre, K.; Boulange-Petermann, L.; Cheynier, V.; Pellerin, P. and Moutounet, M. (1999) Composition of tartrate precipitates deposited on stainless steel tanks during the cold stabilization of wines. Part I. White wines. Am. J. Enol. Vitic. 50:391-397.

Vidal, S.; Courcoux, P.; Francis, L.; Kwiatkowski, M.; Gawel, R.; Williams, P.; Waters, E. and Cheynier, V. (2004a) Use of an experimental design approach for evaluation of key wine components on mouthfeel perception. Food Qual. Pref. 15:209-17.

Vidal, S.; Francis, L.; Williams, P.; Kwiatkowski, M.; Gawel, R.; Cheynier, V. and Waters, E. (2004b) The mouthfeel properties of polysaccharides and anthocyanins in a wine like medium. Food Chem. 85:519-25.

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